

A "BUY QUIET" PROGRAM FOR NASA LEWIS RESEARCH CENTER: SPECIFYING LOW EQUIPMENT NOISE EMISSION LEVELS

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INTRODUCTION

Occupational and community noise exposures at the NASA Lewis Research Center are effectively managed via a three-part program that addresses hearing conservation, community noise control, and noise control engineering [1]. More than 1100 civil servant and contractor employees are included in a hearing conservation program that encompasses OSHA §29CFR 1910.95 [2] and the more stringent NASA Health Standard on Hearing Conservation [3]. The Lewis Research Center Noise Exposure Management Program seeks to limit employee noise exposure and maintain community acceptance for critical research while actively pursuing engineered controls for noise generated by more than 100 separate research facilities and the associated services required for their operation.

Historically, the primary emphasis of hearing conservation work at Lewis Research Center has been on identifying and providing adequate personal hearing protection equipment (e.g., earplugs, muffs) for civil servants and contract employees. Center policy and prudent engineering practice require, however, that these efforts be extended to engineering noise controls in order to reduce source noise levels in the future. To this end, NASA Lewis Research Center has recently implemented a "Buy Quiet" initiative with the goal of achieving long-term reduction of employee noise exposures through purchase of equipment that conforms to hearing conservation program goals. Project designers and engineers who purchase equipment expected to generate noise emission levels of concern for hearing conservation (80 dB(A) and above) are required to consider noise emissions along with other performance criteria. In order to provide

them with the means to effectively pursue this approach, a *Guide to specifying Equipment Noise Emission Levels* [4] has been published.

Regulatory and policy requirements for engineered controls. Engineered controls are required by §29CFR 1910.95 for areas where employee time-weighted-average noise exposures are in excess of 90 dB(A). The NASA Health Standard on Hearing Conservation is more conservative. It requires engineered controls for areas where employees are exposed to noise levels above 85 dB(A). Many areas of the Lewis Research Center approach or exceed these noise exposure levels. Center policy requires implementation of engineered controls, including specification of low-noise equipment whenever possible, to bring existing areas into regulatory compliance and to ensure compliance for new installations. In many work areas, multiple, complex or distributed noise sources have rendered source noise control economically and physically impractical, requiring emphasis on hearing protection and personnel enclosures as the primary means of noise exposure management. In these areas, gradual, yet cost effective, reduction in area noise levels (and employee exposures) may only be achievable as noisy equipment is replaced with less noisy equipment over time.

Practical benefits of selecting low-noise equipment. Selection of low-noise equipment is generally the most effective first step toward reducing noise exposure. Equipment designed for reduced noise emission may be sited and operated more flexibly, improving productivity and reducing reliance on personal hearing protection. In addition, noise control treatments designed and installed by the equipment manufacturer typically provide better equipment accessibility than aftermarket treatments, improving convenience of operation, observation and maintenance. Following a worldwide trend toward design of quieter machinery, many manufacturers have already incorporated adequate noise controls into their standard designs or provide low-noise versions of popular equipment at incremental costs to the purchaser that are small relative to the cost of retrofit noise controls. Industry experience indicates that the added cost for low-noise equipment is approximately .4% to 2.0% of the total cost of a typical project, compared to the cost (in excess of 5%) of retrofit noise controls that may have to be added at a later date.

A "BUY QUIET" PROGRAM FOR NEW EQUIPMENT PURCHASES

To support the "Buy Quiet" initiative, the Noise Exposure Management Program published a *Guide to Specifying Equipment Noise Emission Levels*. The *Guide* covers the development of criteria for noise emission from a broad variety of fixed and portable equipment purchased for use at Lewis Research Center. It is not a standard specification for any particular piece of equipment, but rather is intended to permit designers and engineers to identify appropriate noise emission requirements and incorporate them into comprehensive equipment specifications.

Scope of the *Guide*. The *Guide* is intended specifically for equipment expected to produce noise approaching levels of concern for hearing conservation (80 dB(A) and higher) under a variety of siting and operational conditions and is designed primarily to support hearing conservation goals. Because noise levels that meet hearing conservation requirements are not necessarily "quiet," they may not guarantee an office-like environment in their immediate vicinity. Separate

and potentially more stringent noise emission requirements may apply (and are addressed) where other goals, such as speech communication or community noise, are prominent.

Specialized research models and hardware are exempted from the scope of the *Guide*. New equipment with mechanical power greater than 3,000 HP (2,200 kW) and refrigeration equipment with capacity in excess of 500 tons (60,000 BTU/hr or 60 MJ/hr) may fall outside the scope of the *Guide* and therefore require the implementation of additional or alternative noise control strategies, as do installations on floors above occupied spaces.

Development of the *Guide*. The *Guide* was developed for the Lewis Research Center by Hoover & Keith Inc. of Houston, Texas. Employees from throughout the Center participated in its development and review to ensure that the finished document would be a helpful tool tailored to the needs of Lewis Research Center and easily used by any employee planning the purchase of a relevant piece of equipment. It was specifically designed to be simple and user-friendly to encourage its widespread and voluntary use and to alleviate employee concerns that the *Guide*, intended to become Center policy, would inhibit the procurement process or result in unreasonably tight noise emission specifications taking precedence over other performance criteria. Following the publication of the *Guide*, it was distributed at a number of short training sessions, which were conducted to acquaint employees with the new “Buy Quiet” initiative and with the proper use of the *Guide*.

Employee input was particularly valuable to the development of a comprehensive list of equipment to be covered by the *Guide*. This list includes all relevant items currently in use at the Center as well as equipment purchases planned for the foreseeable future. Unique and specialized equipment required for the support of a large aeropropulsion research laboratory have been accommodated along with standard industrial machinery.

BASELINE NOISE EMISSION LIMITS

Noise emission criteria, which apply to average sound levels at a distance of 1 m, are expressed in terms of the maximum permissible sound level (MPSL) generated by a single piece or package of equipment under a specified load. The expression of the MPSL as an A-weighted sound pressure level (sound level) is appropriate given the primary emphasis on hearing conservation, and simplifies the use of the *Guide*. Criterion levels were selected to support the Lewis Research Center hearing conservation goals and to take advantage of the most current advances in noise control technology.

Equipment covered by the *Guide* is classified into five general groups, each with a corresponding baseline noise emission criterion (see Table 1). Criterion levels for Group 5 (Transformers) are adopted from NEMA TR-1 [5]. The MPSL may differ from the baseline noise emission criterion, depending on seven adjustments that account for various siting and operational characteristics. This flexibility is important in that it allows noise emission requirements to be optimized for each case. Typical specified noise emission levels have been compared with actual acoustical data for many types of available equipment and are believed to be achievable in most cases.

Table 1.	
Baseline Noise Emission Criteria	
Equipment Group	Baseline Noise Emission Criterion, dB(A)
Group 1 Heavy Machinery	85
Group 2 Vents to Atmosphere	85
Group 3 Piping and Ductwork	80
Group 4 Light Machinery	80
Group 5 Electrical Transformers	NEMA TR-1

ADJUSTMENTS FOR SITING AND OPERATIONAL CONSIDERATIONS

Simple procedures enable the user to develop adjustments to the baseline noise emission criterion to account for infrequent and intermittent operation and for siting in remote, outdoor and reverberant conditions. Additional adjustments accommodate the collocation of other high-noise equipment and sound-attenuating enclosures as well as control rooms where speech communication, rather than hearing conservation, is the goal. These adjustments were developed to accommodate typical scenarios and practices found at Lewis Research Center that would justify an increase or decrease in the specified noise emission level for a new piece of equipment.

The adjustments, shown in Table 2, apply to Groups 1 through 4 only; no adjustments are applied to Group 5 equipment. The adjustments are additive and, with one exception (noted in Table 2), are independent of one another. The maximum total adjustment permitted is +25 dB(A). Negative adjustments, which decrease the MPSL, are mandatory, where applicable.

Table 2.	
Adjustments for MPSL (Groups 1-4 only)	
Condition	Adjustment, dB(A)
a. Unattended sound-isolating enclosure Equipment is housed in a structure* that provides significant acoustical isolation and is not occupied by personnel more than 30 minutes per shift during operations.	20
b. Control room and sound-isolating enclosure Adjustment A applies, and a control room, in which clear speech communication is important, is located immediately adjacent to the equipment enclosure.	-10
c. Remote outdoor site Equipment is located outdoors more than 3 m away from areas frequented by personnel or passersby.	5
d. Infrequent operation Equipment is operated at any time during fewer than 15 eight-hour shifts per year.	5
e. Intermittent operations	

Equipment** produces continuous noise for less than 30 minutes per shift and fewer than six times per hour.	5
f. Reverberant environment Equipment is sited in a reverberant*** host space or enclosure.	-5
g. High equipment density More than 5 pieces or packages of noise-emitting equipment are located within a 3 m radius of the piece of equipment being specified.	-5

*Adjustment A does not apply to on-skid enclosures supplied with equipment.

**Adjustment E does not apply to equipment in Group II.

***A graphical method simplifies the determination of whether the host space or enclosure is reverberant. The acoustically absorptive and reflective surface areas (A and R, respectively) of the host space or enclosure are totaled separately. The A and R values are used as coordinates on a graph of the equation $A = (2000-R)/12 \text{ m}^2$. Points falling below the line indicate a reverberant condition; those above the line indicate a non-reverberant condition for the purposes of the *Guide*.

OCTAVE BAND SOUND POWER LEVEL FOR OUTDOOR EQUIPMENT

Maximum octave band sound power levels (PWL) are specified for equipment sited outdoors, whether unenclosed or provided with a vendor-supplied enclosure. The PWL is limited to the spectrum in Table 3, for which the possibility exists of sporadic, nighttime complaints from residents in the nearby community (distance = 800 m). This PWL specification may be more restrictive than the MPSL specification for outdoor sources.

Table 3. Maximum Octave Band Sound Power Levels (dB re 1 pW)								
Octave Band Center Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
All Groups	127	120	113	110	108	107	107	106

USING THE *GUIDE* TO DEVELOP A NOISE EMISSION SPECIFICATION

The *Guide* includes a two-page Noise Emission Worksheet for New Equipment that guides the user through the following steps:

1. select appropriate baseline noise emission criterion
2. select and add appropriate adjustments
3. calculate MPSL
4. report maximum permissible PWL, if appropriate.

The *Guide* also provides recommended specification language, which may be modified as needed and included in the overall equipment specification. A vendor submittal form is

provided, with which the vendor may document and submit measured equipment noise emission data. The primary purpose of the form is to obtain information from the vendor on noise emissions from the equipment and to help identify responsive bidders. Conformance to the specification may be verified by the purchaser using an optional post-installation test procedure. The test procedure defines measurement locations for all equipment groups covered by the *Guide*, corrections for background sound levels and adjustments to free-field conditions.

A computer diskette containing a Microsoft Excel-compatible computer spreadsheet version of the worksheet and an ASCII text file containing the specification language are also furnished with the *Guide*.

SUMMARY

Consistent specification of low-noise equipment is an important component of bringing about reductions in workplace and environmental noise levels, reduction of administrative and operational noise controls, and improvement in the safety, productivity, comfort, and regulatory compliance of the work environment.

NASA Lewis Research Center's "Buy Quiet" approach requires designers and engineers to consider noise emission when purchasing equipment that is expected to generate noise emission levels of concern for hearing conservation (80 dB(A) and higher). The *Guide to Specifying Equipment Noise Emission Levels* supports this goal by providing:

- realistic and achievable baseline noise criteria
- optimization of noise emission criteria based on applicable operation and siting conditions
- template specification language
- vendor submittal forms
- an optional post-installation test procedure.

The format of the *Guide* has been developed with an emphasis on ease of use for persons having only minimal familiarity with acoustics.

REFERENCES

- [1] "A comprehensive approach to management of workplace and environmental noise at NASA Lewis Research Center," B.A. Cooper, *Proceedings of INTER-NOISE 95*, (1995)
- [2] "Occupational Noise Exposure," Occupational Safety and Health Administration Regulation §29CFR 1910, *Federal Register* **48**(46), (1983)

[3] NASA Health Standard on Hearing Conservation, NHS/IH 1845.4, (1991)

[4] D.A. Nelson, *Guide to Specifying Equipment Noise Emission Levels*, Hoover & Keith Final Report No. 1240, (1996)

[5] "Transformers, Regulators and Reactors," NEMA Standards Publication No. TR-1-1993, National Electrical Manufacturers Association (1994)

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